

Training a New Generation of Research Scientists

*Livermore's postdoctoral
researchers gain invaluable
experience while strengthening
the Laboratory's technical
expertise.*

Bioscientist Kris Kulp (far right)
reviews experimental results with
three Laboratory postdocs (from
front to back): Miranda Sarachine,
Bryan Hudson, and Ben Stewart.



Lawrence Livermore National Laboratory

ACHIEVING a Ph.D. in a scientific or engineering field symbolizes the pinnacle of higher education, but it rarely marks the end of training. The sheer amount of technical knowledge required and the myriad challenges involved in conducting pioneering research in many fields demand advanced training beyond the doctoral degree. Such training is particularly valuable when it is acquired under the mentorship of a senior researcher and offers access to advanced computational and experimental facilities such as those at Lawrence Livermore.

For the Laboratory, historically bent on attracting the nation's top talents in science and engineering, having a strong program that sponsors postdoctoral researchers, or "postdocs," for two to three years has proven invaluable. What began as a small, informal effort conducted independently by various research directorates has grown substantially during the past decade, especially in the last few years. Livermore's Postdoc Program now provides much greater coordination and oversight and operates with strong encouragement from Department of Energy and Lawrence Livermore senior managers.

In 2009, 112 new doctoral degree recipients, among the most promising scientific researchers in the nation and the world, were given the opportunity to pursue research at Livermore. Two years later, that number has grown to 177. An allied program, the Lawrence Postdoctoral Fellowship Program, founded in 1997, typically accepts two to four participants annually. (See the box on pp. 6–7.)

"Postdocs bring to the Laboratory many of the most recent advances taking place in academic departments at top universities worldwide," says bioscientist Kris Kulp, director of the Institutional Postdoc Program Board, which oversees the Livermore program. "These scientists and engineers are essential for maintaining the intellectual capabilities we need." While working at the Laboratory, postdocs make significant contributions to basic

and applied research of national interest, from investigating dense plasmas of ions to elucidating the mechanics of climate change. “Postdocs add to the breadth and depth of Livermore’s scientific capabilities,” Kulp says, “and they help inspire established research teams with their creativity and enthusiasm.”

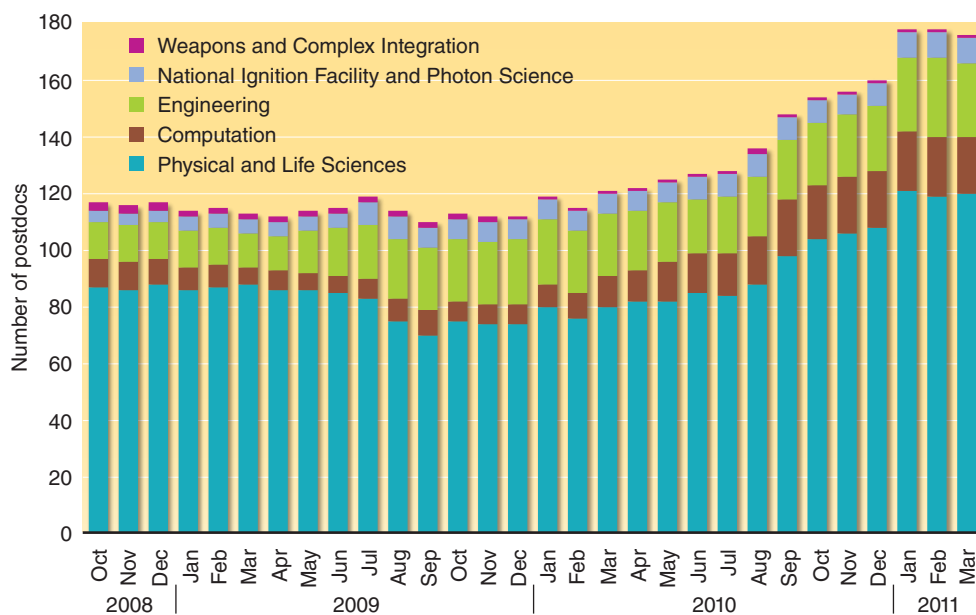
Young Ph.D.s learn about the program from advertisements in scientific journals, the Laboratory’s career Web sites, scientific conferences, and faculty who are affiliated with Livermore scientists. Many applicants hear about the program while attending one of Livermore’s summer institutes for both undergraduate and graduate students.

Postdocs are selected for their scientific expertise, publishing record, and enthusiasm for working in the Laboratory’s highly collaborative environment. Their positions offer a competitive salary, fringe benefits, and travel opportunities. Successful candidates are hired for one or

two years, depending on the program, and terms can be extended up to three years—an opportunity most postdocs choose to take. About one-third of the applicants selected are non-U.S. citizens.

During their tenure, postdocs conduct research and sharpen their scientific expertise in their chosen field. Every postdoc is assigned a mentor, a senior scientist or engineer who guides the research and helps the postdoc acquire the skills necessary to advance his or her career. These skills include developing research plans, writing proposals, publishing results, and presenting their findings at national meetings. Perhaps most importantly, these young researchers have an extended opportunity to establish collaborations both within and outside the Laboratory.

Chemist John Knezovich, director of Livermore’s University Relations Program, oversees collaborations between the Laboratory and the academic community



Lawrence Livermore has significantly increased the number of postdoc positions since 2008, as shown in this graph of the month-by-month postdoc population.

In addition to its historic postdoctoral program, the Laboratory also supports the Lawrence Postdoctoral Fellowship Program, known informally as the Lawrence Fellowships. Initiated in 1997, the program is a tribute to Nobel laureate and Laboratory cofounder Ernest O. Lawrence. The highly competitive program provides recipients with three years of scientific freedom at Livermore to pursue experimental, theoretical, or computational projects of their own design.

Lawrence Fellowships are awarded to candidates who have exceptional talent, established track records in scientific pursuits, and the potential for significant achievements. Fellows are free to work on projects and with mentors of their choice. This freedom, coupled with the Laboratory’s interdisciplinary atmosphere, permits many fellows to investigate other scientific fields. On completing the fellowship’s term, recipients may choose to stay at the Laboratory as one of their career options.

A committee with representatives from the Laboratory’s mission-related organizations chooses the Lawrence Fellows each year. An applicant pool of a few hundred is reduced to six individuals, who then participate in a two-day interview. Two to four of those six individuals are selected for fellowships. (See *S&TR*, November 2002, pp. 12–18.) Particularly talented applicants not chosen as Lawrence Fellows are frequently offered traditional postdoctoral fellowships or staff positions.

“We expect Lawrence Fellows to bring something new to the Laboratory and take us in new directions,” says Livermore chemist John Knezovich, who directs the University Relations Program. Indeed, fellows have produced remarkably creative research during their tenure. For example, Knezovich points to chemist Aleksandr Noy and physicist Olga Bakajin. While working as Lawrence

In E. O. Lawrence's Image

Fellows, they built a versatile hybrid platform that uses lipid-coated nanowires. Mingling biological components in electronic circuits could enhance biosensing and diagnostic tools, advance neural prosthetics such as cochlear implants, and even increase the efficiency of future computers.

In 2010, Noy, Bakajin, Francesco Fornasiero, and Sangil Kim received an R&D 100 Award for filtration membranes composed of carbon nanotubes aligned on a silicon chip the size of a quarter. Developed in partnership with Porifera, Inc., in

Hayward, California, with early support from Livermore's Laboratory Directed Research and Development Program, the nanotechnology could make water desalination more efficient and cost effective. (See *S&TR*, October/November 2010, pp. 12–13.) The two former Lawrence Fellows, now career scientists at Livermore, have taken entrepreneurial leaves of absence to work with Porifera, where Bakajin is the chief technology officer and Noy is the chief science officer. Noy is also an associate adjunct professor at the University of California at Merced.

Second-year Lawrence Fellow Andrea Kritcher graduated from the University of California at Berkeley in nuclear engineering. She also interviewed for and was offered a staff position with the Laboratory as well as a conventional postdoc position, but she accepted the Lawrence Fellowship because of the unusual freedom the award affords. "For some researchers coming out of graduate school, it's very valuable to have an opportunity to develop more fully as a research scientist before taking a staff position," she says.

Kritcher has two Livermore mentors: physicist Siegfried Glenzer, with whom she began working as a graduate student, and physicist Lee Bernstein. In one of her projects, she is using x-ray Thomson scattering to characterize fusion targets for ignition experiments at the National Ignition Facility (NIF), in which 192 laser beams will compress and heat the hydrogen isotopes deuterium and tritium to the point of fusion.

"We're diagnosing the compression-phase temperature and density conditions of these implosion capsules," Kritcher says. "We want to achieve low temperature and high density to reduce entropy and enable efficient capsule compression to the ultrahigh densities needed for ignition." Kritcher has conducted initial experiments using the OMEGA laser at the University of Rochester's Laboratory for Laser Energetics. "I feel lucky to have this opportunity," she says. "Scientists hope to have ignition on NIF within the next couple of years, and some people have waited their entire careers for this event."

Kritcher is also looking at how nuclei interact with dense plasmas. She is planning experiments on the OMEGA laser to study nuclei-plasma interactions in thulium and osmium. She adds, "These basic science experiments are relevant to NIF-type plasmas as well as astrophysics."



Physicist Andrea Kritcher, shown here with a laser optic at the Laboratory's Jupiter Laser Facility, is in the second year of a Lawrence fellowship. Her work involves characterizing fusion targets and conducting research on nuclei-plasma interactions.

to strengthen science teaching and help develop the future scientific and engineering workforce. Knezovich worked as a Laboratory postdoc in the early 1980s, one of only 12 at the time. More recently, he says, “We’ve built an organization around the postdocs and are paying attention to them as a group.”

Pipeline for Staff Positions

Knezovich notes that besides invigorating research programs, postdoctoral appointments represent an important pathway toward filling new career positions. “The Postdoc Program is a critical component of our strategy for attracting world-class scientific talent,” he says. “It’s a significant part of our workforce hiring process.” Historically, about half of the appointees have converted to staff positions at the end of their tenure. In 2010, that number rose to 62 percent.

“Our goal is to provide an experience that prepares them well for any job they

may have in the future, either at Livermore, another national lab, academia, or industry,” says Kulp. “If they don’t stay, we want them to maintain a relationship with the Laboratory.” Some who find positions in academia, for example, become collaborators in various research programs and recommend their graduate students apply for postdoc positions at Livermore.

Many postdocs receive support from a specific research project, typically sponsored by the Laboratory Directed Research and Development (LDRD) Program, which applies internal research and development funds to potentially high-payoff projects at the forefront of science. Positions may also be supported by external sources such as the Department of Energy’s Office of Science. “The Department of Energy and its National Nuclear Security Administration expect us to invest in the future of our workforce,” says Knezovich, “and LDRD funding is an excellent means to that end.”

In addition to funding provided by research projects, the Laboratory supports time for postdocs to devote to professional development and networking. Examples include conducting research that is more general in nature but not funded by a project; writing papers and proposals; and attending seminars, conferences, and workshops. (See the box on p. 9.)

PLS Home to Most Postdocs

Postdocs work in one of Livermore’s mission-related organizations: Physical and Life Sciences (PLS), Computation, Engineering, Global Security, Weapons and Complex Integration, or National Ignition Facility and Photon Science. The majority of them find a home in PLS, where about 120 postdoctoral fellows conduct research in physics, chemistry, life sciences, earth science, and materials science.

In the last two years, the postdoc population in PLS has increased about 73 percent, from 70 to more than 120. Geochemist Annie Kersting, director of the Glenn T. Seaborg Institute, oversees the Postdoc Program for PLS. Kersting meets regularly with postdocs to make sure they are on track with their research goals as well as focused on their careers.

“Postdocs bring new scientific skills to the Laboratory and make many important scientific contributions to Livermore’s programs,” she says. The decision to offer a postdoc a staff position is determined by the postdoc’s skill set and achievements during the fellowship as well as the funding outlook for programs needing that person’s expertise. “Whether they stay on or not, we want them to maximize their time here and prepare for a career as an effective researcher.”

Geologist Jennifer Matzel converted to a staff position in 2010, following a three-year term as a postdoc. After obtaining a Ph.D. in geology and geochemistry from Massachusetts Institute of Technology, Matzel accepted a postdoc position with the Berkeley Geochronology Center and the University of California at Berkeley.



Marisa Pedretti, a postdoc in the Physical and Life Sciences Directorate, describes her research to physicist Chris Hagmann at the 2010 Institutional Postdoc Poster Symposium. The daylong symposium is an annual event, allowing postdocs to discuss their research with Livermore scientists and engineers.

Taking Care of Postdocs

“The Laboratory is committed to providing a rewarding experience for our postdocs,” says Kris Kulp, head of Livermore’s Institutional Postdoc Program Board, which evaluates the quality and effectiveness of the program. The board is composed of representatives from all Livermore organizations that sponsor postdocs as well as the Strategic Human Resources Management Directorate.

The board fosters professional development activities throughout the year. Each year, the board holds a one-day postdoc workshop that focuses on career development. The board also sponsors the Lawrence Livermore Postdoc Association (LLPA), which organizes informal social activities for the young scientists and engineers. A monthly brown-bag seminar series addresses topics that help postdocs better understand the Laboratory, with question-and-answer sessions featuring senior managers such as Director George Miller. Once a year, all postdocs present results from their work at a daylong poster symposium, where they can meet and talk with Laboratory scientists about their current research.

The Laboratory’s mission-related organizations also sponsor activities for their postdocs. For example, the Physical and Life Sciences Directorate holds semi-monthly seminars that feature talks from postdocs, allowing the presenters to practice giving general talks to scientists not in their immediate field of research. The directorate also offers awards each year for best research and best mentor. Other organizations might devote seminars to career development topics, such as how to write a proposal or search for a new job, and reviews of major Livermore programs and initiatives. Occasionally, past postdocs who are now on the Laboratory’s staff provide insights from their experiences.

LLPA is run entirely by the current postdocs with the goal of fostering a community environment for the new

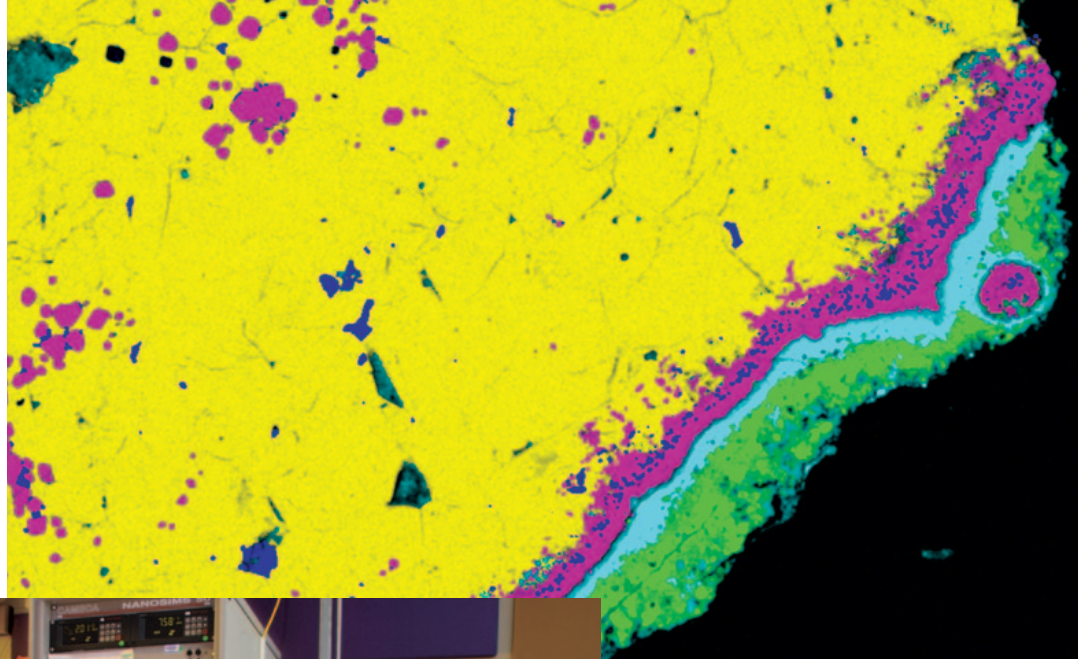


Postdoc Eric Wang uses the GYRO code developed by Jeff Candy at General Atomics to study microturbulence in plasmas confined by powerful magnetic fields, as shown in the background image. A theoretical physicist, Wang also serves as president of the Lawrence Livermore Postdoc Association.

researchers. The association organizes monthly lunches, an annual summer barbecue, and regular social gatherings (movie nights and happy hours). The LLPA Handbook also provides advice for living in the San Francisco Bay Area and navigating the Laboratory. The handbook recommends places to live, resources for finding rentals, and information on local stores, utilities, and transportation options.

The current LLPA president is Eric Wang, a theoretical physicist in the third year of his postdoc term. “We do our best to welcome new members, put on social events, and provide career guidance,” he says. He adds that the association meets regularly with the board to discuss questions, concerns, and successes.

Wang’s research focuses on simulating microturbulence in tokamak plasmas. Scientists hope that tokamaks, which use magnetic fields to confine a plasma, will one day provide abundant energy through continuous fusion reactions. “If we can control microturbulence, we’ll have much steeper temperature gradients,” says Wang. “A fusion reactor would then be much smaller and cheaper to develop.” Wang received a Ph.D. in plasma physics from the University of California at Los Angeles, where his adviser was collaborating with Livermore physicist Bill Nevins. Wang is one of six postdocs working in the Laboratory’s Fusion Energy Sciences Program.



Livermore geologist and former postdoc Jennifer Matzel is part of a research team examining calcium-aluminum-rich inclusions in samples of the Allende carbonaceous chondrite meteorite, which fell to Earth in 1969. The compositional x-ray image (above) shows the rim and margin of an inclusion that is about 4.6 billion years old. Studies such as this one are helping researchers better understand how a solar system forms.

While there, she heard two Livermore chemists speak about nuclear forensics and decided to investigate postdoc opportunities at the Laboratory.

At Livermore, Matzel studied dust particles brought back by the Stardust space mission and samples collected from meteorites. For this research, she used a nanometer-scale secondary-ion mass spectrometer (NanoSIMS), an instrument designed to measure the elemental and isotopic concentrations of very small particles. Matzel examined the particles' isotopic composition, looking in particular for "daughter" products of an isotope of aluminum with a half-life of about 700,000 years. Information obtained from

the analysis is helping scientists better understand how the solar system formed billions of years ago.

As a staff member, Matzel is continuing her cosmochemistry research and working in the field of nuclear forensics. In particular, she is studying boron isotopes found in graphite obtained from nuclear reactors. "The isotopes tell us about the reactor's history," she says, adding that her current activities are especially multidisciplinary. "My work involves biology, nuclear forensics, cosmochemistry, and geochemistry, so I'm learning about many new fields."

Her husband, Eric Matzel, is a seismologist at Livermore. She notes

that the diverse scientific programs at Livermore make it an attractive research institution for two-career couples.

Engineering Builds Success

Diane Chinn, division leader for Engineering Technologies, oversees the Postdoc Program for the Engineering Directorate. "There's a certain kind of engineering postdoc who wants to work at a national lab," says Chinn. "Typically, that person is looking to apply a narrow area of expertise. This candidate may toy with the idea of academia or be interested in industry, but those options may not offer a postdoc much say over which projects to work on."

As with other directorates, Engineering advertises, recruits on major university campuses and at national conferences, and encourages applicants through its relationships with many professors. The efforts have paid off handsomely. A few years ago, Engineering employed only one to three postdoc engineers, but in 2011, 27 are on the job.

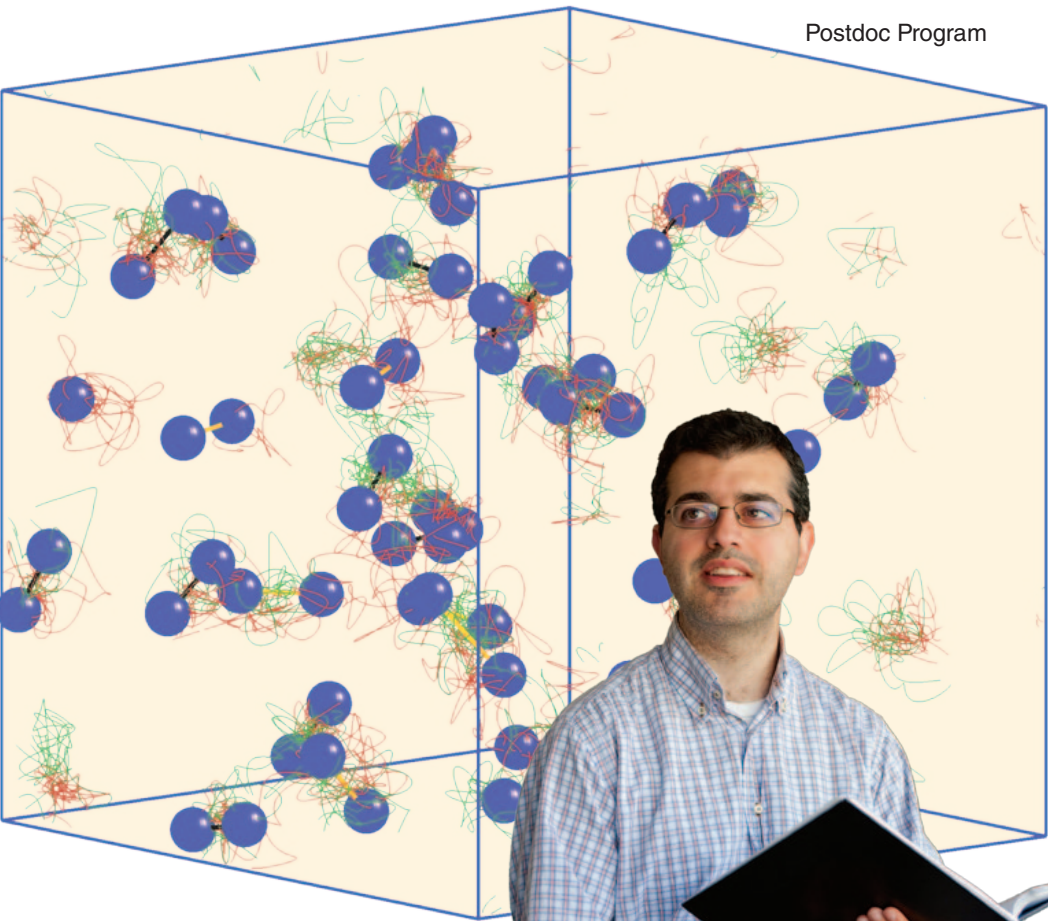
“Postdocs have a narrow and deep understanding of their fields,” Chinn says. “They bring us engineering technology out of universities that is state of the art.” LDRD funding pays about one-third of Engineering’s postdoc salaries. The remainder is a combination of institutional and programmatic funding.

Candidates for Engineering’s postdoc openings face a similar vetting process to that in other directorates, which includes traveling to Livermore for an interview and presenting a seminar on their graduate research. Occasionally, managers recognize that a strong candidate is better suited for a staff position than a postdoc fellowship.

Up to 70 percent of applicants offered postdoc positions agree to join Livermore. Chinn says the high percentage is a telling indicator of the Postdoc Program’s strength because many engineering candidates receive offers from other institutions. About 50 percent of the postdoc engineers eventually convert to staff positions at the conclusion of their third year. Those who leave usually go on to jobs at a university or in industry. Wherever the former postdocs land, their mentors strive to maintain relationships and encourage collaborations.

Computation Doubles Its Postdocs

In the past two years, the Computation Directorate has nearly doubled its number of postdocs, from 12 to 22. “The Postdoc Program is our primary means of attracting new staff into research positions,” says Jeff Hittinger, the directorate postdoc advocate and a computational scientist at the Center for Applied Scientific Computing (CASC). Hittinger notes that there is a



Postdoc Saad Khairallah, a computational physicist, is simulating the behavior of hydrogen. Behind him is a screen shot from a path-integral Monte Carlo simulation showing hydrogen molecular bonds stretching as the electrons become excited under extreme conditions. Blue spheres are hydrogen protons; red and green lines are electrons.

tremendous amount of competition among employers for new Ph.D.s in computer and computational science. However, few places offer Livermore’s breadth of research—from computational physics and applied mathematics, to data mining, visualization, computer architectures, and high-performance computing—along with ready access to some of the world’s most powerful supercomputers.

While the LDRD Program supports many Computation postdocs, a significant number are funded through programs sponsored by the Office of Advanced Scientific Computing Research in the Department of Energy’s Office of Science. For example, the Scientific

Discovery through Advanced Computing Program, known as SciDAC, is aimed at solving the computational challenges involved in developing future energy sources, studying global climate change, designing new materials, improving environmental cleanup methods, and advancing physics.

Third-year CASC postdoc Saad Khairallah, a computational physicist, graduated with a Ph.D. in condensed-matter physics from the University of Illinois. His thesis adviser was David Ceperley, a former Livermore researcher. Khairallah was accepted into the Postdoc Program after meeting his current mentor, Erik Draeger, at a scientific conference.

Draeger, a computational physicist, had also been a postdoc before joining the Livermore staff.

Khairallah is involved in three research efforts. First, he is helping develop new algorithms for path-integral Monte Carlo calculations to simulate the behavior of hydrogen from first principles. Results from this work will have important applications to National Ignition Facility experiments, astrophysics research, and simulations of the physical processes that occur during a nuclear weapon detonation.

"Although hydrogen is the simplest element in nature, it is nevertheless challenging to fully predict its properties," says Khairallah. "Achieving this capability would influence many areas of research because hydrogen makes up roughly 74 percent of the elemental mass of the universe. If I were not at Livermore, I could not have done such computationally intensive work."

Khairallah is also part of a large team effort that is led by Livermore physicist

Frank Graziani and includes collaborators from other national laboratories. The project involves large-scale molecular-dynamics simulations of high-energy-density plasmas. Khairallah notes that his experience as a Livermore postdoc has been good. "People here value postdocs and listen to them," he says.

Finally, he is exploring a computational technique called nudged elastic band that is designed to show at the atomic level the path a physical system takes as it transitions to a final state after undergoing, for example, a chemical reaction. "We are asked to think about new algorithms to take advantage of petascale and exascale computing," says Khairallah, "and I believe the nudged elastic-band technique is a great candidate for the new generation of machines."

Future Scientific Leaders

Physicist Heather Whitley is another former postdoc who converted to a staff position following a three-year term at Livermore. Whitley, who received a

Ph.D. from the University of California at Berkeley, notes that scientific fields are constantly evolving and that knowledge and techniques learned in one field can often be applied to another, particularly in the Laboratory's multidisciplinary environment. She says, "We all bring different expertise to the table. Hopefully, we all learn to listen to each other."

Livermore managers overseeing the Postdoc Program expect the program to continue to thrive and grow, as scientific fields cross traditional boundaries. "Postdocs do great research," says Kersting. "They are a talented bunch of up-and-coming scientists, and we're very happy to have them here."

—Arnie Heller

Key Words: Institutional Postdoc Program Board, Lawrence Postdoctoral Fellowship Program, Postdoc Program, postdoctoral research, University Relations Program.

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